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ART. I.—*An Account of Four Cases of Gunshot Wounds, Involving Bone and Implicating the Knee-Joint, treated by Free Incisions into the Joint, with Comments.* By JOHN A. LIDELL, M. D., Surgeon U. S. Volunteers.

GUTHRIE says, that “wounds of the knee-joint from musket-balls, with fracture of the bones composing it, require immediate amputation.” Vide *Commentaries on the Surgery of War*, p. 94, American edition.

Esmarch says, that “all gunshot injuries of the knee-joint, in which the epiphysis of the femur or tibia has been affected, demand immediate amputation of the thigh. It is a rule of deplorable necessity, already given by the best authorities, and which experience fully confirms. In vain have we often made the attempt to leave the case to nature, to save an unhappy man the loss of his limb, on account of a slight injury; but just so often have we had cause to repent that amputation had not been performed in the first instance.” *Statham's Esmarch*, p. 107, American edition.

But the mortality attending secondary amputation of the thigh, especially for gunshot injury of the osseous tissue entering into the structure of the femoro-tibial articulation, is very great. A large majority of the cases treated in this way terminate fatally. For this reason, among others, it has been proposed to try another operative procedure in these cases, when for any cause primary amputation has not been practised, with a view to diminish the risk of a fatal termination, and, at the same time, to save the limb, if such a consummation be perchance within the limits of possibility. The operative procedure to which the writer refers, consists in opening the wounded and inflamed joint by incisions made to such an extent, and in such a manner, that any accumulation or stagnation of decomposing and ichorous pus in the joint cavity shall be impossible.

The conservative surgeon might be induced to give a fair trial to this method of treating gunshot wounds of the knee-joint, complicated with

injury of the femoral condyles or the head of the tibia—primary amputation having not been performed, and the secondary period having arrived—for two very good reasons: *Firstly*, clinical observation has shown that those cases of gunshot wound of the knee-joint do the best, when left to nature, wherein the joint happens to have been opened extensively by the projectile; and *secondly*, the success which has attended the treatment of suppurative idiopathic synovitis by free incisions, as recommended and practised by Mr. Gay, Mr. Barwell, and others. Their idea, the correctness of which is not questioned by anybody at present, is that a suppurating joint has lost its physiological characteristics as an articulation and has become, to all intents and purposes, an abscess; and, as such, will be benefited by the plan of treatment found useful for accumulations of matter in the dense tissues of other portions of the body, viz., free incisions. It has been suggested that one cause of the great amount of constitutional disturbance which always accompanies suppurative inflammation of any of the large joint-cavities, is the confinement of the pus within the dense, unyielding fibrous and osseous walls of the joint; and hence great benefit is always derived in such cases from letting the matter out.

But to return to our starting point. Stromeyer, in at least one instance, practised the kind of experimental surgery which we have under consideration. He says:—

“As experience has taught that those wounds of the joint (knee) in which it had been extensively opened have been the most inclined to terminate favourably, amputation not having been practised, I was led, on account of the frequent fatal termination of amputation of the thigh, to make the following attempt: In the case of a young man, a musket-ball had struck the joint near the patella externally, and made its exit three inches backward and upward, comminuting a portion of the outer condyle or rather deeply grooving it. At first it was doubtful whether the joint was opened; when this became certain, I laid open the track of the bullet, removed many small fragments, and made on each side of the joint an incision two inches in length through the soft parts and the lateral ligaments. From these openings the puriform synovia readily escaped, and the condition of the patient was for some weeks everything that could be wished. The suppuration decreased in a short time and the wounds had a healthy appearance, but the patient died of abscesses in the lungs.” *Statham's Stromeyer*, p. 65, American edition.

Before introducing the following cases, it should be remarked that three out of the four plainly demanded primary amputation, in the opinion of the writer; that none of them reached a general hospital until the secondary period had arrived, and that secondary amputation did not promise a successful result in a single one of them, on account of the extension of the inflammatory mischief up the thigh, in a severe form, in all of them. It remained, therefore, at our option either to leave these cases to the resources of nature alone, or to treat them by free incisions made into the inflamed and injured joint.

CASE I. *Gunshot wound of the left knee-joint, with fracture of the patella; treated by free incision; fatal from diarrhœa and exhaustion.*—Corporal George W. Moser, Co. B, 51st Pennsylvania Volunteers, aged 34 years, was admitted to Stanton General Hospital, 25th May, 1864, from the field, having sustained a gunshot wound of the left knee-joint thirteen days previously (12th May), near Spottsylvania C. H., Va. A conical musket-ball passed through the fore-part of that joint from side to side, fracturing the patella with comminution, but not injuring the condyles of the femur, or the head of the tibia.

The knee was much swelled and inflamed when he came to the hospital. The thigh, also, was a good deal swelled. The wounds of entrance and exit were both open and discharging a thin, dark-coloured, dirty-looking pus. He had much constitutional disturbance; a hot skin, a feeble and rapid pulse, much general debility, and diarrhœa. He was gradually getting worse. It was thought that he did not possess sufficient stamina to undergo an amputation of the thigh with success. Besides, it happened at this time that all secondary amputations turned out very badly. For these reasons the following operation was performed :—

June 2, 1864. The patient being under sulphuric ether, a longitudinal incision was made on the outer side of the joint extending from the head of the tibia nearly to the top of the external sub-crural pouch, and exposing the interior of the joint to that extent. The fragments of the broken patella, three in number, were then extracted. The operation was attended with the loss of but little blood, and with the advent of but little shock. A straight splint, well padded, was applied to the inner side of the limb in such a manner as to secure complete immobility of the joint. The ice dressing was ordered to be kept on the knee, and the interior of the joint to be washed out at short intervals by an injection consisting of a weak solution of the permanganate of potassa. It was also directed that he should be supported by a nutritious diet, assisted by tonics (*ferri et potass tart.*), and by stimulants (*porter and wine*). The next day after the operation he appeared to be much better in every respect, and for several days afterwards he appeared to be doing well. The wound of operation took on a healthy action, and began to granulate in a satisfactory manner. The improvement was so marked in every respect that we began to entertain some hopes of his recovery.

8th. It was noticed that he was failing in strength, notwithstanding the supporting treatment. He also had much diarrhœa. After this he continued to grow weaker day by day, emaciating all the while, until he died, 12th June, ten days after the operation, of exhaustion. He was entirely free from pain, and towards the last was somnolent, but his intellect was always found to be clear on rousing him. The wound of operation continued to do well to the end.

The profuse and persistent diarrhœa appeared to be one of the chief causes of the debility and marasmus which exhausted and finally destroyed this patient. At times there was a remission of the diarrhœa, and it was observed that he always appeared to be better at such intervals. The discharges from the bowels became very profuse towards the last. But, as already intimated, the wound of operation continued to secrete a laudable pus and to fill up with healthy-looking granulations, notwithstanding that he was growing weaker and thinner from one day to another.

We failed to obtain an autopsy because the patient's brother was present and took possession of the body immediately after death. In all probability a *post-mortem* examination of the intestinal canal would have revealed the exact relation which existed between the diarrhoea and the fatal result, and, on that account, it is a subject of regret that an autopsy was not held. The patient himself informed us that he had diarrhoea for some time before he was wounded, and that it had never entirely left him since that event.

CASE II. *Gunshot wound of the left knee-joint, with very oblique fracture within the lower third of the femur, treated by free incisions into the joint; death by exhaustion five days afterwards.*—Private Benjamin Wise, Co. I, 170th New York Volunteers, aged 28 years, was admitted to Stanton General Hospital, June 4, 1864, from the field, having been severely wounded, ten days previously (May 25), in the left knee-joint, with a very oblique fracture of the femur, just above the condyles, by small-arms, on the North Anna River. A rifle-bullet (conical) penetrated the joint from the front, a little above and to the outer side of the patella, and, passing obliquely backwards and upwards, escaped behind. The line of fracture extended from the external condyle across the femur, so as to terminate on the inner side, some five or six inches above.

The knee was very much swelled when the patient was brought to the hospital. It was also hot, tender, and painful. On compressing it, a thin, dirty-brown-coloured pus escaped from both the orifices of entrance and exit. The thigh likewise was much swelled, up to the hip. The subcutaneous veins were large and blue-coloured; they could be distinctly traced all the way up to the groin. When admitted to the hospital, he did not have much constitutional disturbance; but the thigh was already too much swelled and infiltrated with the products of inflammatory action to admit of successful amputation at this time. Moreover, the results of secondary amputations were proving to be very unfavourable, even in cases that seemed to be favourable at the outset. Prescribed absolute quietude of the limb, nutrients and opiates *pro re nata*, and the ice dressing to the inflamed joint. But little change in his condition occurred for several days.

June 8. About midnight he took a severe chill, which lasted half an hour. He became feverish afterwards, and the pain in the joint was increased.

9th (morning). He is much worse. He has a good deal of irritative fever, which has supervened since yesterday; countenance anxious; skin hot; pulse 108, and quick. He also complains of an intense aching pain in the joint. His constitution appears to be unusually vigorous, but the thigh is so much swelled and inflamed as not to justify amputation through it. Accordingly the following operation was performed as a remedial measure of dernier resort:—

The cavity of the joint was freely opened by two longitudinal incisions, each rather more than four inches in length, and made through the internal and external lateral ligaments respectively. Several small pieces of bone were extracted through the incision on the outer side of the joint. It was noticed that the peri-articular tissues of the affected knee were greatly thickened by serous infiltration. Sulphuric ether was employed as an anæsthetic. But little blood was shed, and no "shock" was occasioned by the operation. The joint contained a quantity of dark-coloured, dirty-looking matter. Directed suitable extension of the limb to be made by a weight attached to the

leg through the agency of adhesive plasters, and a cord passing through a hole in an upright standard firmly fastened to the foot of the bed. Thus the weight was suspended beyond the foot of the bed. Directed the limb to be propped up by long sand-bags placed on each side of it so as to keep it steady; ice dressings to the joint to be continued.

10th. He expresses himself as entirely relieved from pain, and he has no fever. Ordered supporting treatment (nutrients and tonics), together with the ice dressing to knee. He appeared to be getting on comfortably in every respect till June 13, when it was noticed that he was failing rapidly, although the joint appeared to be doing well, and the swelling of the thigh was manifestly abating. Ordered free stimulation and alcoholics.

14th. He continued to sink, and died in the afternoon, of exhaustion. No autopsy.

The relief to the patient afforded by this operation, with respect to both the intense distress in the injured knee and the symptoms at large of irritative fever, was prompt, decided, and very striking; and while the operation did not rescue the patient from death, nor even prolong his days to any extent worth mentioning, it must be acknowledged, at the same time, that it produced greater relief from intense suffering than the writer has ever seen produced in similar cases by any other remedial measure whatever, except amputation of the thigh. This operation, then, performed in a case which did not admit of secondary amputation, was beneficial, because of the great comfort which it afforded the patient. However, this interesting fact should not incline us to forget that primary amputation ought to have been practised in this case as soon as possible after the injury.

CASE III. *Contusion of the external condyle of the left femur by a glancing bullet; secondary inflammation of the knee-joint treated by free incisions; termination fatal.*—Private Thomas Pryor, Co. H, 18th Massachusetts Volunteers, aged 19 years, was admitted to Stanton General Hospital, May 25, 1864, from the field, having been wounded at the battle of the Wilderness, Va., May 5, twenty days before, by a glancing minie ball, which caused a superficial wound of the skin and subcutaneous areolar tissue on the outer side of the left knee; the joint was not opened by the bullet.

At the time of his admission to hospital the knee was swelled, painful, and tender. The wound was about the size of a franc piece. The tissues at the wound were ashy-gray in colour, and sloughing. A very small opening into the joint, about the size of a pin-head, had been made by the slough, from which a thin flaky pus could be squeezed out. The leg was flexed on the thigh to about a right angle. The tenderness of the joint was very great.

The general condition of the patient was very bad. His countenance exhibited a dusky-red colour; skin hot and dry; pulse quick, small, and very frequent (130); he was weak, delirious, and had muscular tremors (subsultus tendinum); tongue dry, and of a bright-red colour. He was thought to be in too low a condition to bear amputation, and, under the peculiar circumstances of the case, it was deemed advisable to perform the following operation:—

June 6, 1864. The inflamed knee-joint was freely opened by two longi-

tudinal incisions, each about three inches in length, and made, the one on the inner and the other on the outer side of it; the lateral ligaments were then divided subcutaneously with a tenotome. A quantity of thin flaky pus escaped. The synovial membrane was found to be red and thickened, especially in the subcrural pouches. The loss of blood during the operation was trifling, and there was no "shock." The anæsthetic employed was sulphuric ether.

After-treatment.—The leg was brought down straight immediately, and secured by roller bandages to a straight splint well padded and placed behind the articulation, so as to extend from the ischial tuberosity to the heel and beyond it. The ice dressing was continued on the knee, and nutrients, tonics, and stimulants were administered internally.

June 8. He appeared much better. His pulse was about 108; skin cool, soft, and moist; tongue moist and clean; his delirium had departed, his countenance was clear and cheerful, and he expressed himself as free from pain; but he had no appetite.

10th. He was failing rapidly, and he died on that day, of exhaustion.

From the great severity of the constitutional disturbance, the presence of idiopathic fever had been suspected; but, at the autopsy, it was found that there was not any lesion whatever of the intestines and of the mesenteric glands, that the liver was not bronzed, and that the spleen was not enlarged or softened. The febrile movement was therefore, in all probability, neither idiopathic nor malarial, but purely sympathetic of the mischief in the knee-joint. It was also found at the autopsy that the *external condyle* of the femur was *contused by the glancing bullet*, although the synovial sac was not penetrated by it. *The contused bone exhibited well-marked ecchymosis* through a circular space about one inch in diameter by three-fourths of an inch in depth, and was surrounded by a distinct line of demarcation, which was beautifully shown by making a section through it with a saw. The contused portion of bone exhibited a dark reddish-brown colour. The interior structure of the epiphysis in general was redder than natural. The femoral condyles were not denuded of cartilage. The lungs exhibited pneumonia in the first stage (active hyperæmia). There was no thrombus in any of the veins, and no abscesses in any of the organs.

The relief from prominent and urgent symptoms was produced as promptly and as strikingly in this as in the last case; but, in both alike, the operation appeared to be of no avail to rescue the patient from impending death. The subject of *contusion of bone*, which is introduced by this case, is very interesting. It is, however, foreign to our present inquiry, and, besides, would require more time than can now be bestowed, in order to make a satisfactory exposition of it.

CASE IV. Gunshot wound, with fracture of the left femur in the lower third, implicating the knee-joint; treated by free incisions; death by exhaustion.—Private John A. Mackey, Co. A, 7th New York Heavy Artillery, aged 21, was admitted to Stanton General Hospital, 4th June, 1864, from the field, having a gunshot wound, with fracture of the left femur, in lower third close to knee-joint, inflicted 30th May, 1864, at Gaines' Hill, Va., by a conical bullet (musket), which entered the front of the thigh, just above the sub-crural synovial pouch, and, passing through the limb backwards and slightly upwards, escaped behind. The femur was fractured

obliquely in its lower third, but the amount of comminution appeared to be not great.

The left knee was greatly swelled, painful, and very tender, on careful examination, at time of admission to hospital. The thigh, also, was much swelled as high as the hip and groin. A thin, dirty-looking pus flowed from the wounds. The track of the bullet was emphysematous. On compressing the knee-joint the flow of this illy-elaborated matter was increased. The cavity of the joint had probably been opened by the lower end of the upper fragment of the broken femur.

The patient's general condition was very bad. His countenance was pale, pinched, and almost hippocratic; tongue inclined to be dry; pulse weak and very frequent (about 140). He was daily becoming more debilitated. It was obvious that he could not bear amputation, even if the tissues of the thigh were sound enough to permit that operation. It was equally obvious that he must speedily succumb to his injuries unless art should interfere successfully in his behalf. Accordingly, the following operation was employed as a remedy of last resort:—

June 8, 1864. The injured knee-joint was laid freely open by two longitudinal incisions three or four inches in length, and made directly over the external and internal lateral ligaments respectively, so that any subsequent accumulation of matter in the cavity of the joint became impossible. A detached fragment of bone, about one inch in length, was extracted through the incision on the outer side of the joint. The patient was insensible from sulphuric ether. The joint contained some thin, dark-coloured, dirty-looking pus. The loss of blood was trifling. There was no "shock." Directed the leg to be kept extended by a weight attached to it by means of adhesive plasters, etc., and suspended over the foot of the bed. Ordered the ice dressing to be kept on the knee, and nutrients and alcoholic stimulants to be administered as freely as he would take them.

9th. He expressed himself as feeling more comfortable, but was in reality no better.

10th. He was rather weaker, but free from pain.

11th. He died from exhaustion.

At the autopsy the femur was found to be fractured, with much comminution, about four and one-half inches above the femoro-tibial articulation. The lower end of the upper fragment (shaft) was *denuded of periosteum and gangrenous to the extent of about two inches*. Here the *compact tissue was white*, and the *marrow dirty, grayish-brown in colour*, and *very offensive in odour*. *Above the gangrenous section the marrow was bright-red in colour (red inflammatory marrow of Virchow)*. The upper end of the lower fragment (epiphysis) was also *gangrenous*, but not to the same extent. There was *no thrombosis*. There were *no secondary abscesses* in any part of the body.

The autopsy of this case proves that extensive comminution of the femur may sometimes exist, in connection with a gunshot fracture of that bone; and, at the same time, the surgeon be unable to detect the extent of the comminution, however careful his exploration of the wound with his finger. In such cases it will often be found that the osseous fragments are lying in close proximity to each other, their original relations having been but little

disturbed, and that they are firmly held in such relationship by the fibrous and other strong tissues situated immediately exterior to them.

Conclusions.—It may be stated, in a general way, that the result of the cases narrated in this paper is not calculated to encourage the practice of treating wounds of the knee-joint, complicated with injury of the neighbouring osseous tissue, by the method of incisions, for not one of them eventuated in recovery. Indeed, all of them terminated in death by exhaustion within a comparatively short time after the operation; and there was also a remarkable uniformity in the phenomena pertaining to their fatal close. In all of them the first effect of the incisions into the joint appeared to be highly beneficial, being attended with marked relief from the local pain and with marked diminution of the constitutional disturbance or irritative fever. But in no case was this improvement permanent; for, after an interval of time which appeared to depend somewhat upon the severity of the injury to bone, but it was generally brief, symptoms of extreme debility supervened in every one of them, and death by exhaustion followed soon afterwards, in spite of the liberal use of alcoholic stimulants and the liberal employment of the supporting treatment.

With regard to Case I. there is, in the opinion of the writer, ample room for doubt whether this patient would have recovered under any plan of treatment whatever that could have been employed. This opinion is predicated upon the persistence and the severity of the diarrhœa which had attacked the patient prior to the infliction of the gunshot wound of the knee-joint and patella, and afterwards accompanied that injury to the fatal close. It is certain that he was steadily progressing downwards from bad to worse while the cure of his injury was left to nature, that he died subsequently, having been treated by incisions, and it is extremely difficult to conceive how primary amputation of the thigh could have placed him in a better condition to resist the exhausting effects of the disease of his chylopoietic viscera.

With regard to Cases II. and IV., both of which were instances of gunshot fracture of the femur in its lower third, complicated with injury of the knee-joint, it is not probable that any method of treatment less thorough than amputation of the thigh could have prevented a fatal termination; and, in the opinion of the writer, there is no doubt but that operation ought to have been practised at the outset. In both these instances the result shows that amputation should not have been deferred beyond the primary period. Early amputation would have afforded these patients the following advantages: First, that pertaining to the primary operation, which is, in general, more successful than the secondary operation in the ratio of about two to one; and in the second place immediate amputation would not have left them exposed to a sudden kindling up of inflammation in the injured thigh so intense and wide-spread that amputation could not be successfully performed after its establishment. This misfortune befell

both these patients; and it is well known that the same misfortune has happened to many other patients, and is very apt to happen to all suffering from wounds of a similar character. It is, therefore, to be deeply deplored that these unfortunate soldiers were deprived of that chance of recovery which amputation of the thigh, performed during the primary period, might have afforded. I know not how other surgeons may justify themselves for delaying to amputate in these and similar cases (viz., gunshot wounds of the knee-joint, with fracture of the femur or the tibia within or near the articulation), but as for myself, in view of what the great masters in military surgery, speaking to us from the past, unite in saying upon this subject; in view of the mournful results which, according to all experience, have followed this class of injuries of the knee-joint when treated without amputation, I should not only consider myself as unjustifiable in neglecting to amputate for such injuries, but should also deem myself guilty of a criminal omission in the discharge of professional duty.

Concerning Case III. it should be remarked, that the essential features of the injury were all dependent upon the *contusion of the external condyle* of the femur, occasioned by the glancing bullet. Without entering into an extended account of the pathological facts pertaining to *contusion of bone*, it may, with propriety, be stated in this place that the contusion was severe enough to destroy the vitality of a circumscribed portion of the external condyle of the femur, that this dead bone acted as an irritant in the same way as other foreign bodies, and that by such irritation an inflammatory action was kindled in the parts surrounding it, including the knee-joint. Now, it is evident that, in order to cure this joint inflammation, it was indispensable that the focus of irritation should be removed, that the portion of bone necrosed by means of the contusing-process should be extracted or excised by surgical art; and this would have required the performance of the operation of resection of the knee-joint for its accomplishment.

The other alternative was the amputation of the suffering member. During the primary and the early part of the secondary period the choice lay between resection of the knee-joint and amputation of the thigh. It is well known that resection of the tibio-femoral articulation, for traumatic lesions especially, is one of the most fatal operations known to surgery, so fatal, indeed, that it is deemed unjustifiable in military practice. There can be no doubt, then, that amputation of the thigh seasonably performed afforded the best and about the only chance of saving this patient's life.

It may be permitted in this place to remark further, that this case illustrates an important fact of which the writer has seen many other examples, viz., the exceeding gravity of all cases of severe *contusion of bone*. Indeed, the writer is inclined to class this injury among the most formidable of those inflicted by the missiles of war. It is also a subject upon which, hitherto, but little has been written. It is, therefore, comparatively new, fresh, and important, and demands to be considered in a separate place.

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